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METHOD OF MANUFACTURING A MICROMECHANICAL COMPONENT

Background Information

Although it may be applied to any micromechanical components and structures, in particular to sensors and actuators, the present invention and the underlying problem are elucidated with reference to a micromechanical yaw rate sensor or acceleration sensor having a trenched micromechanical function layer that is manufacturable using silicon surface micromachining technology.

Both surface and volume micromechanical process steps are performed with such micromechanical components. Volume micromechanical processes are used in processing the back of components. To do so, the wafer with its front side already structured is rotated and placed with this side on handler systems or instrument mounts.

There may be contamination of the front side, i.e., particles may be deposited on the structured surface. In subsequent front side etching processes, these particles can be transferred to the underlying layers. The subsequent process steps may result in freely mobile particles which impair the functioning of the respective micromechanical component.

A method has been proposed for using a temporary protective layer made of aluminum to protect the front side while processing the back. After processing the back, this protective layer is removed by a wet chemical process during which particles on the surface are underetched and lifted. However, this process is complicated and expensive, because additional process steps and mask levels are required.

Summary Of The Invention

The method according to the present invention for manufacturing a micromechanical

component has the advantage that the germanium protective layer on the front side protects the structured layers beneath it from particles during the back process. The particles are thus deposited on the protective layer and can be removed together with the protective layer in a wet chemical etching process.

Germanium as a protective layer has the advantage that it can be deposited in a low-temperature (<450°C) LPCVD process, so that it is compatible with aluminum. The deposition rates are about 50 nm/min. It is also possible to grow germanium selectively on silicon vs. silicon dioxide. In order to deposit germanium on oxide, a polysilicon nucleation layer is required. The germanium layer can be structured using the dry etching or plasma etching methods known in semiconductor technology. Using germanium as the protective layer for the front side of the wafer has the advantage that it can be removed after the back process by a wet chemical process using a medium containing hydrogen peroxide (H_2O_2). In the wet chemical process, the particles on the wafer surface are underetched and are also removed. Germanium can be removed selectively with respect to oxide, nitride, aluminum and silicon by wet chemical processes. Due to this selectivity and the low-temperature deposition process, this method is compatible with the standard CMOS processes. Since germanium is attacked by standard cleaning processes (RCA, piranha), alternative cleaning methods such as O_2 plasma must be used. However, it is also possible to cover the germanium layer with a CVD oxide. This oxide layer may then be removed using hydrofluoric acid at a later time, when the germanium will not be attacked. Since germanium is not attacked by KOH, it can be used as an etching mask in back processes. This permits KOH etching without an etching box.

According to a preferred embodiment, the substrate has a wafer substrate, a first sacrificial layer provided thereon and a micromechanical function layer provided thereon, the micromechanical function layer forming the front side and the wafer substrate forming the back.

According to another preferred embodiment, a first hard-surface mask is formed on

the front of the substrate, and the protective layer containing germanium is formed selectively in the openings in the hard-surface mask.

According to another preferred embodiment, the protective layer containing germanium is formed over the entire surface of the back of the substrate.

According to another preferred embodiment, a first hard-surface mask is formed on the front side of the substrate, and the protective layer containing germanium is formed over the entire surface of the hard-surface mask.

According to another preferred embodiment, the protective layer containing germanium is formed over a nucleation layer covering the entire surface.

According to another preferred embodiment, a second hard-surface mask is formed on the back of the substrate, and a cavern is etched in the back with the front side covered at least partially by the protective layer containing germanium.

According to another preferred embodiment, after etching the cavern, the protective layer containing germanium is removed from the front side and then trenches are etched in the micromechanical function layer by using the first hard-surface mask.

According to another preferred embodiment, the second hard-surface mask is formed from the protective layer containing germanium on the back.

Brief Description Of The Drawings

Figures 1-6 show schematic diagrams of the manufacturing process for a yaw rate sensor according to a first embodiment of the present invention in a cross section.

Figures 7-11 show schematic diagrams of the manufacturing process for a yaw rate sensor according to a second embodiment of the present invention in cross section.

Figures 12-15 show schematic diagrams of the manufacturing process for a yaw rate sensor according to a third embodiment of the present invention in cross section.

Detailed Description

In the figures, the same reference symbols identify the same components or components having the same function.

Figures 1-6 show a schematic block diagram of the manufacturing process for a yaw rate sensor according to a first embodiment of the present invention in a cross section.

According to Figure 1, first and second oxide layers 2, 3 are applied to the front and back sides of a base substrate 1 made of silicon. Then in a subsequent process step, a thick polycrystalline silicone layer 4 is deposited on the front side. A third oxide layer 5 is deposited on polycrystalline silicone layer 4 and is structured by a photolithographic process. Structured third oxide layer 5 functions as a hard-surface mask in a trench process carried out after the back process.

If, after structuring third oxide layer 5, the wafer were rotated for processing on the back, third oxide layer 5 could be scratched or damaged by the contact with the instrument mounts. The resulting particles could penetrate into openings 6 in structured third oxide layer 5 and stick there. In the subsequent trench process for structuring polycrystalline silicone layer 4, the particles would be transferred into openings 6 in layer 4. Freely mobile particles could be formed by subsequent process steps and could interfere with the functioning of a micromechanical component. This could be prevented by a temporary germanium protective layer 7 which is grown selectively in this embodiment.

Germanium protective layer 7 is grown selectively in openings 6 in the hard-surface mask of third oxide layer 5, as shown in Figure 2. The layer is grown in a low-temperature (<450°C) LPCVD system. Since openings 6 are filled with germanium,

no particles can be deposited in these openings. Particles on oxide mask 5 or on germanium protective layer 7 do not have any effect on the trench process. In particular, particles added during the back process on germanium protective layer 7 are also removed in subsequent removal of this layer 7 by a wet chemical method.

After applying germanium protective layer 7, the wafer is rotated for processing on the back, as shown in Figure 3. A nitride layer 8 is applied to the back of the wafer. Nitride layer 8 and second oxide layer 3 beneath it are then structured. Layers 3, 8 then function as an etching mask for a subsequent KOH etching process in which, for example, a cavern 9 is etched into substrate 1 from the back. After the KOH etching, layers 3, 8 are removed and the wafer is turned again for the processes on the front.

As shown in Figure 4, germanium protective layer 7 in openings 6 is then removed in a wet chemical process with a medium containing hydrogen peroxide (H_2O_2).

Silicon layer 4 is then structured as illustrated in Figure 5, producing trenches 10 by the known trench process. If particles or residues were to remain in openings 6 in wet chemical etching of germanium protective layer 7, they would not have any effect on structuring of silicon layer 4, because germanium is etched with the same etching process as silicon.

Then the hard-surface mask of third oxide layer 5 is also removed. Figure 6 shows the wafer after the process on the front/back is concluded.

Figures 7-11 show a schematic cross-sectional diagram of the method of manufacturing a yaw rate sensor according to a second embodiment of the present invention.

In this second embodiment, germanium protective layer 7' is grown over the entire surface of the front side of the wafer with the help of a thin polycrystalline silicon

nucleation layer 11, as illustrated in Figure 7.

Structured third oxide layer 5 is completely protected by germanium protective layer 7' over the entire surface. Therefore, in processing the back, the oxide mask of third oxide layer 5 cannot be damaged, and particles may be deposited only on the surface of germanium layer 7'.

Polysilicon nucleation layer 11 is deposited on the front and back of the wafer at the same time. Nucleation layer 11 is then removed from the back of the wafer.

After applying germanium protective layer 7', the wafer is rotated for processing on the back, as shown in Figure 8.

A nitride layer 8 is applied to the back of the wafer as in the first embodiment. Nitride layer 8 and third oxide layer 3 beneath it are then structured. Layers 3, 8 function as an etching mask for the subsequent KOH process in which a cavern 9, for example, is etched into substrate 1.

Layers 3, 8 are removed after the etching process, and the wafer is rotated for the processes on the front. As shown in Figure 9, germanium protective layer 7' is then removed in a wet chemical process by using a medium containing hydrogen peroxide (H_2O_2), leaving polysilicon nucleation layer 11. This layer 11 is removed in the subsequent structuring of silicon layer 4 in which trenches 10 are produced by the trench process, as shown in Figure 10.

Then the hard-surface mask is removed from third oxide layer 5. Figure 11 shows the wafer after conclusion of the processing on the front/back.

Figures 12-15 show a schematic cross-sectional diagram of the method of manufacturing a yaw rate sensor according to a third embodiment of the present invention.

In KOH etching processes on the back, germanium may be used as the etching mask, because it is not attacked by KOH. This begins with a layered structure such as that illustrated in Figure 12. There is a second oxide layer 3 on the back of the wafer.

Since germanium will grow wherever silicon is present, a germanium protective layer 7″ such as that illustrated in Figure 13 is obtained on the front and back.

After applying germanium protective layer 7″, the wafer is turned for processing on the back. Germanium protective layer 7″ on the back of the wafer is then structured by a photo process and a dry etching process. Structured germanium protective layer 7″ on the back then functions as an etching mask in the subsequent KOH etching process, as indicated in Figure 14.

Germanium layers 7″ on the front and back are then removed in a wet chemical process by using a medium containing hydrogen peroxide, as illustrated in Figure 15. Further structuring is then performed as described above with respect to the first and second embodiments.

Although the present invention was described above on the basis of preferred embodiments, it is not limited to them but instead can be modified in a variety of ways.

In particular, the specific choices of basic materials and layer materials have been given only as examples.